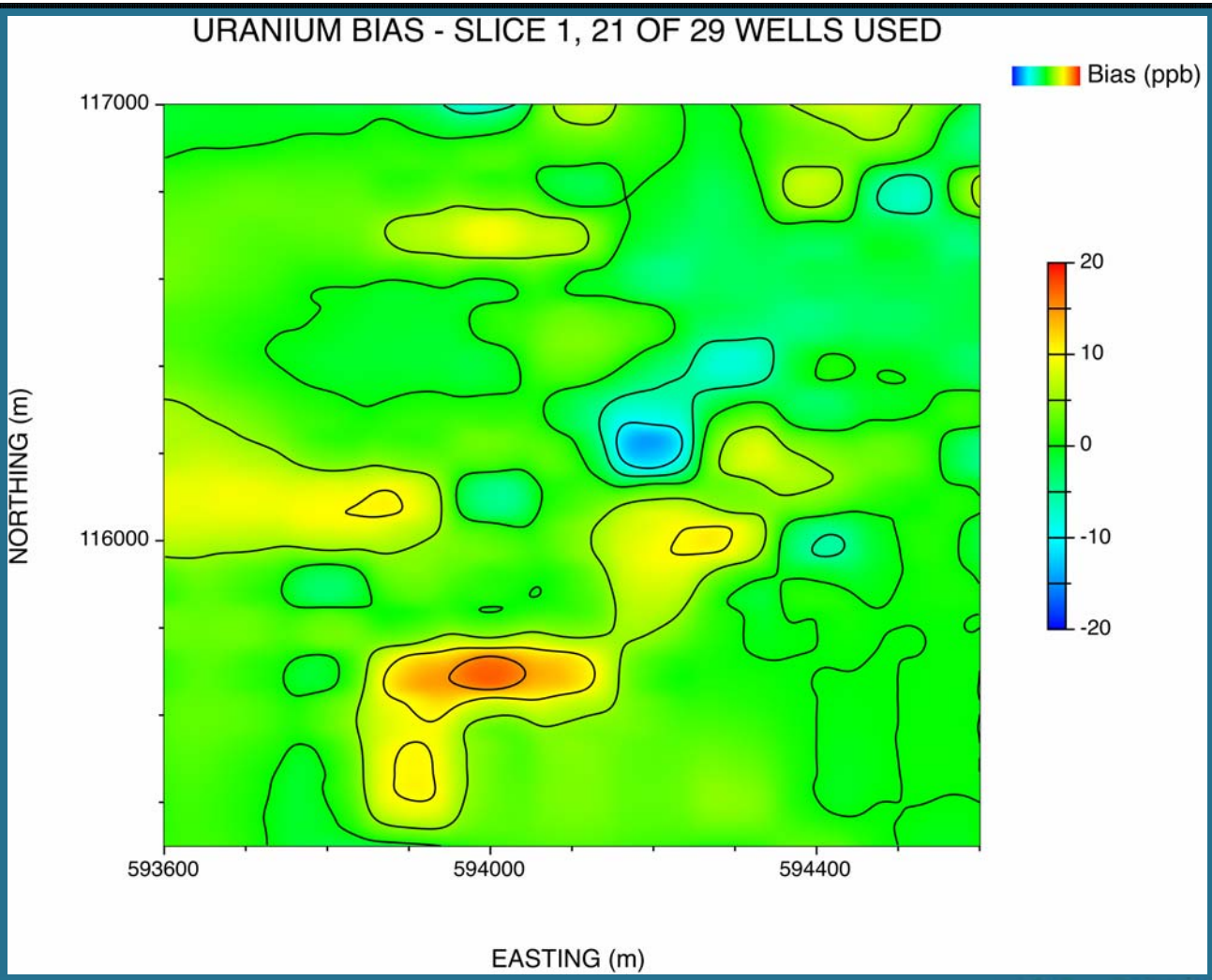
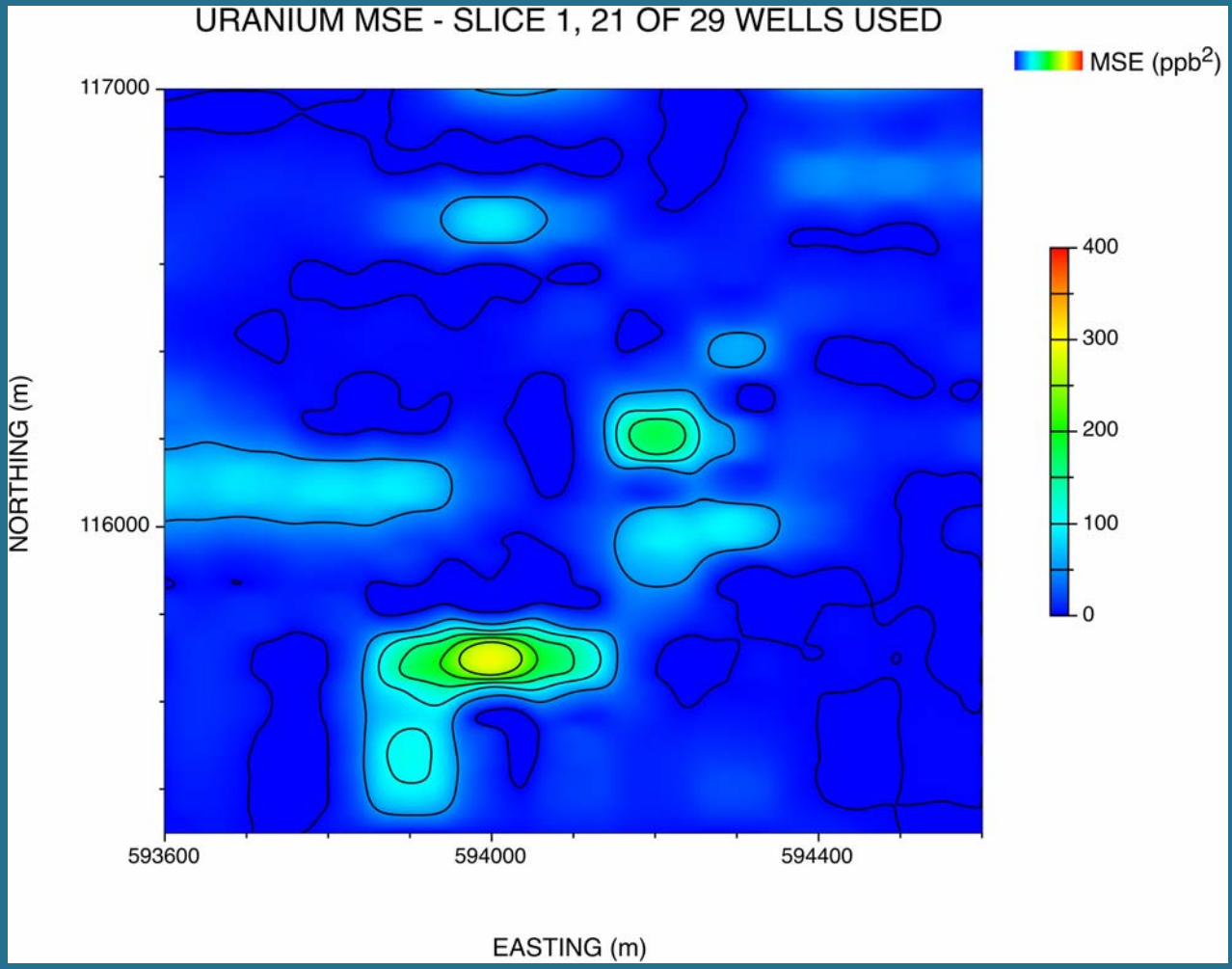
Iterative Data Removal

- Steepest descent approach
  - One well removed at each stage
  - Pick location which least increases bias, uncertainty of MILR estimates at known sample locations
- Move to next stage
  - Periodically estimate entire mesh with remaining wells
  - Compute bias, uncertainty compared to base map

Bias Map Example



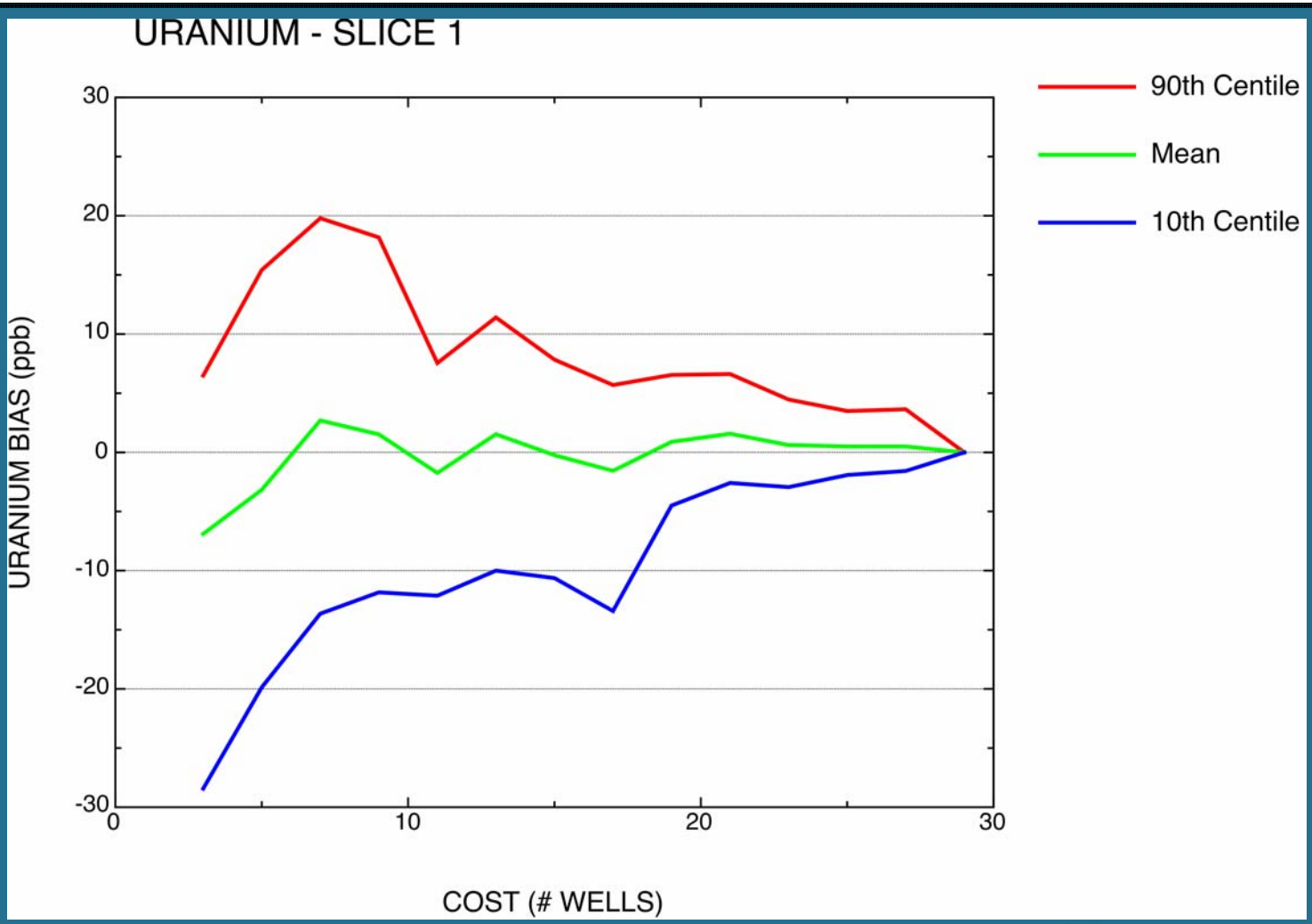
Uncertainty Map Example



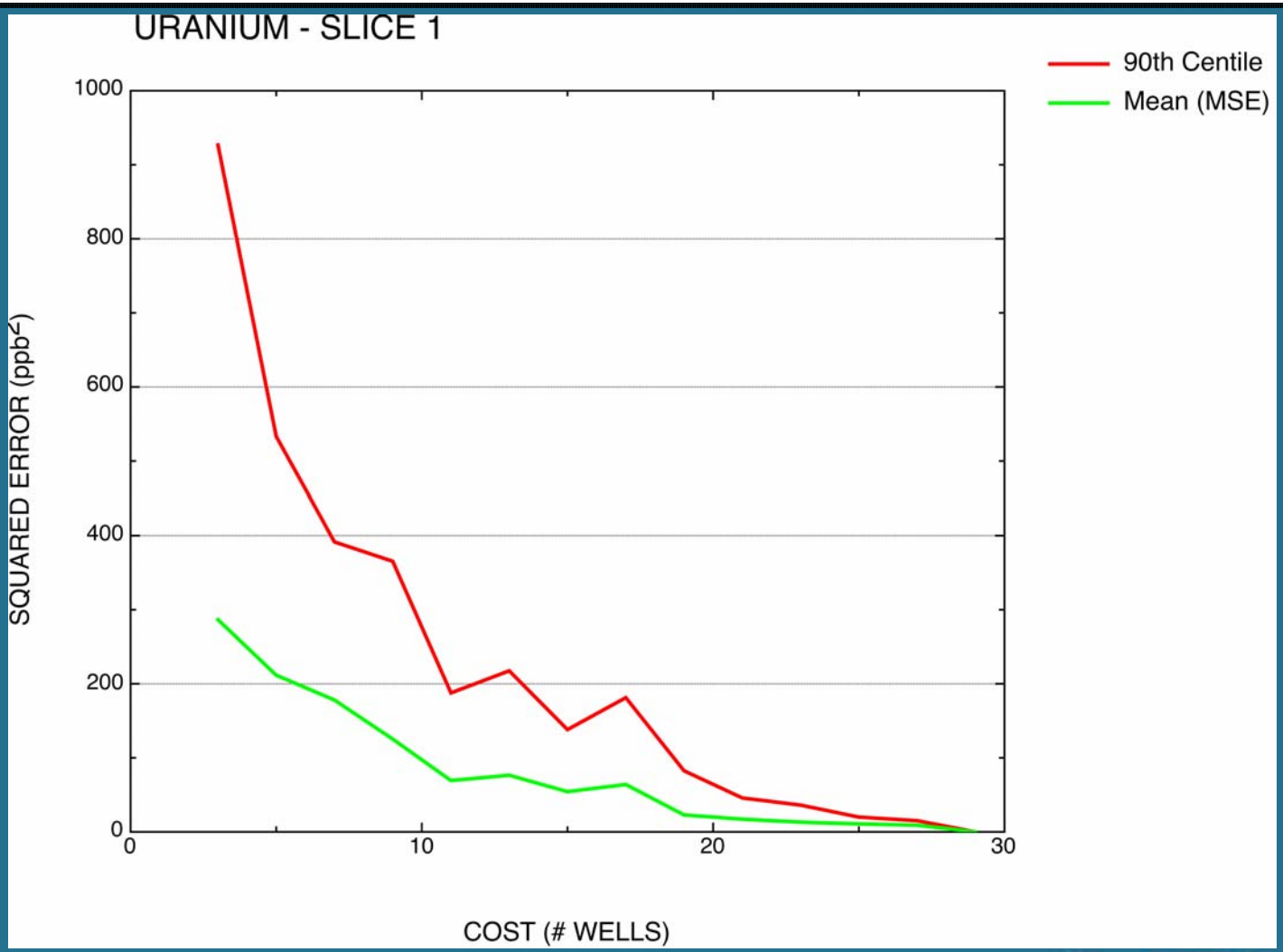
Cost-Accuracy Tradeoffs

- GTS balances cost of network vs.
  - Global & local bias
  - Global & local uncertainty (MSE)
  - Algorithm looks at both concentration & probability scale measures
- Results distilled in tradeoff curves

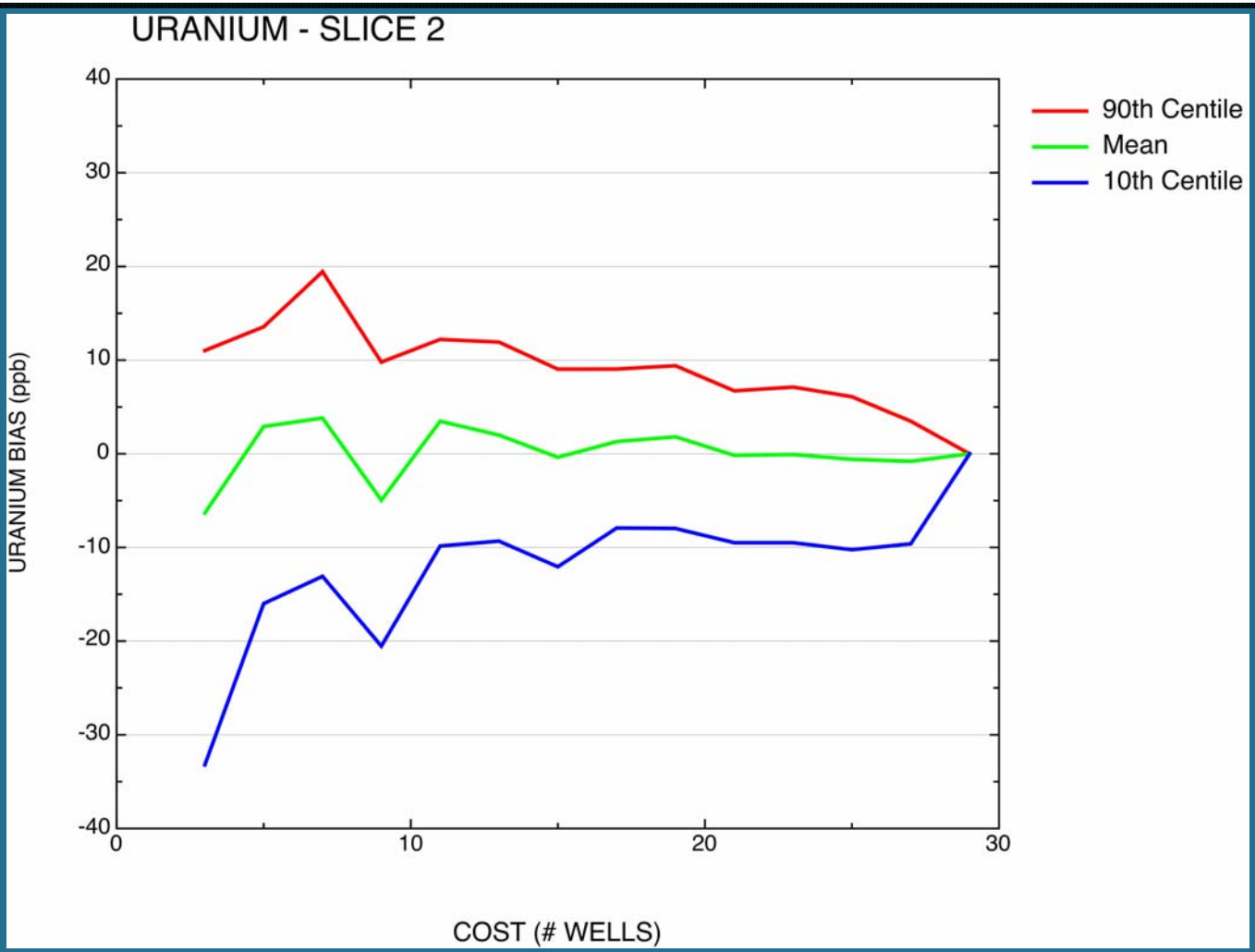
Uranium Slice 1 Bias



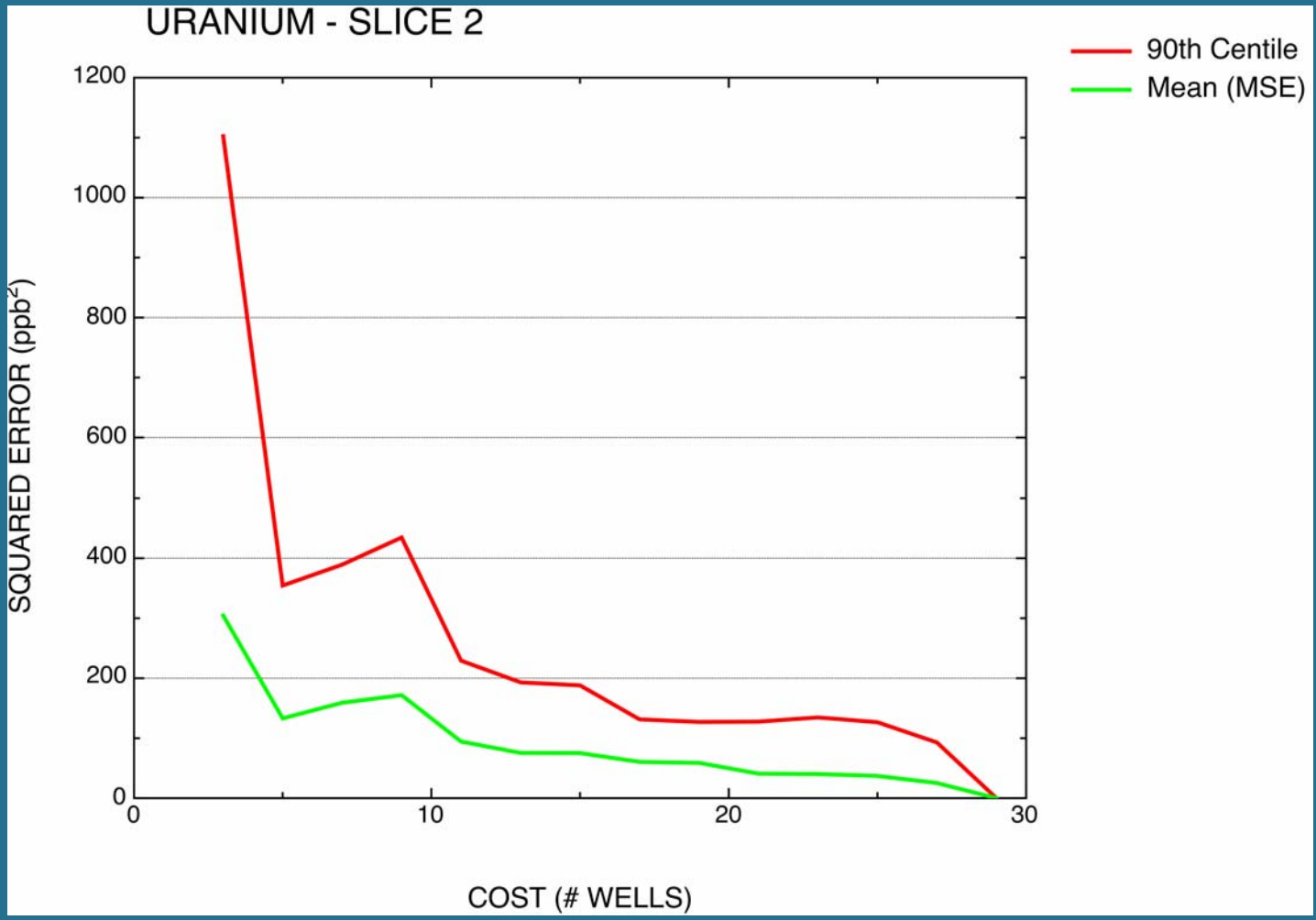
Uranium Slice 1 MSE



Uranium Slice 2 Bias



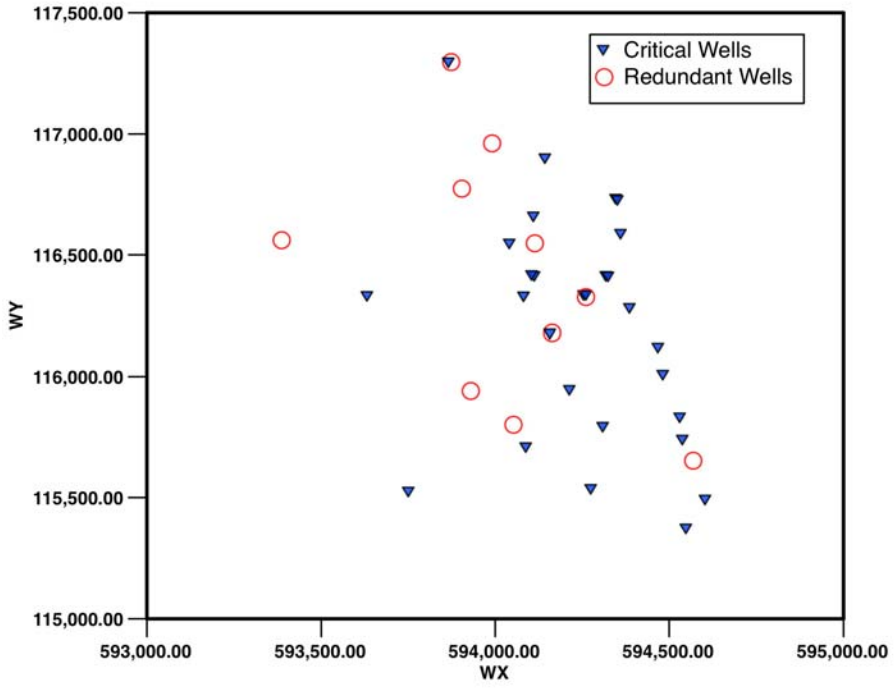
Uranium Slice 2 MSE



Removal Per Slice

Time Slice	% Removed	N Wells
1	28%	8 of 29
2	41%	12 of 29
3	27%	9 of 33
4	19%	6 of 32

Optimal Uranium Network



Optimizing by Addition

- Existing network may not provide adequate coverage
  - Should any wells be added?
- GTS uses misclassification probabilities
  - Relative to regulatory limit, MCL
  - Uranium limit = 30 ppb
  - Areas with high chance of misclassification are candidates for new wells

Benefits of CCDF

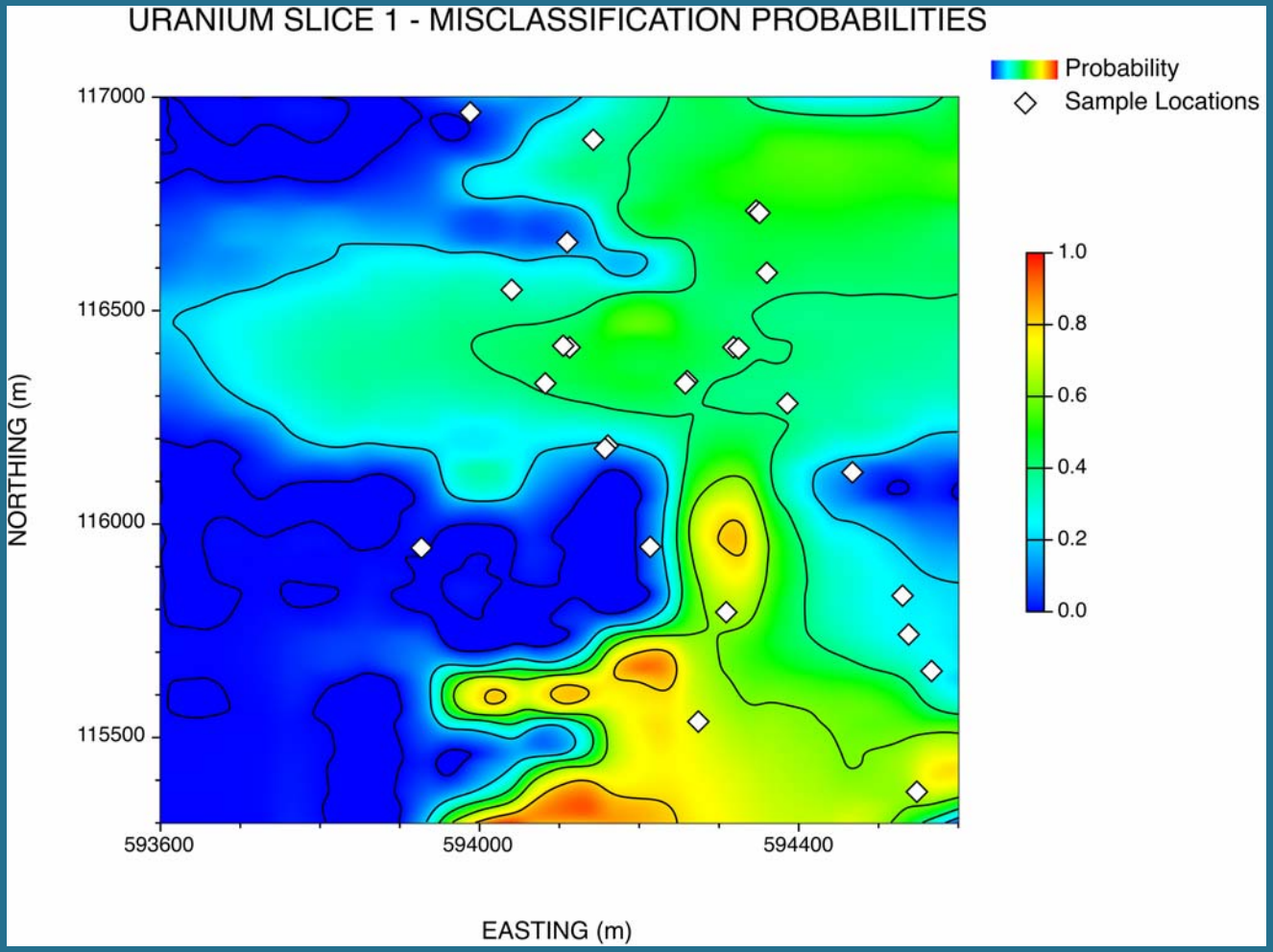
- CCDF = Conditional Cumulative Distribution Function
- MILR estimates unique CCDF at each mesh point
  - Depends on surrounding samples
  - Probabilities bounded by observed indicator data

Misclassification Computation

- False positives
  - Pr {True ≤ MCL | Estimate > MCL}
  - Computed using CCDF at each pixel
- False negatives
  - Pr {True > MCL | Estimate ≤ MCL}
- These probabilities are mapped using recent data

LTMO

Uranium Misclassificaton Map



Summary

- GTS provides:
  - Flexible optimization
    - Temporal, spatial, or both
    - Optimize by subtraction and/or addition
    - Choice of temporal approaches
      - Temporal variogram (less historical data)
      - Iterative thinning (longer historical record)
  - Defensible optimization
    - Highly empirical
    - Quasi-nonparametric estimation
    - Stakeholders can negotiate level of removal

Summary (cont.)

- GTS provides:
  - Visual emphasis
    - Variograms, time series graphs
    - Trend maps
    - Bias & uncertainty maps
    - Base maps
    - Cost-accuracy tradeoff curves
    - Optimal network plots
    - Misclassification maps

Thanks and…Go GTS!

Kirk Cameron, Ph.D.
MacStat Consulting, Ltd.
Colorado Springs, CO
(719) 532-0453

LTMO